ISSN (print) 0093-4666 © 2011. Mycotaxon, Ltd. ISSN (online) 2154-8889

MYCOTAXON

http://dx.doi.org/10.5248/117.53

Volume 117, pp. 53–85 *July–September 2011*

Lepiota (Agaricales) in northern Thailand – 1. *L.* section *Stenosporae*

P. Sysouphanthong[1,3*], K.D. Hyde[1,3,4], E. Chukeatirote[1], A.H. Bahkali[4] & E.C. Vellinga[2]

[1]*School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand*
[2]*Department of Plant and Microbial Biology, University of California at Berkeley, Berkeley, CA 94720-3102 U.S.A.*
[3]*International Fungal Research and Development Centre, Research Institute of Insect Resources, Chinese Academy of Forests, Bailongsi, Kunming, Yunnan Province 650224, P.R. China*
[4]*Botany and Microbiology Department, College of Science, King Saud University, P.O. Box: 2455, Riyadh 1145, Saudi Arabia*
*Correspondence to: *phongeunsysou@gmail.com*

Abstract —Eleven species of *Lepiota* section *Stenosporae,* reported as new for Thailand, are fully described and illustrated. Five are compared with European and North American collections based on nrITS sequence data. Two species possess a cutis-like pileipellis (*L. aureofulvella, L.* sp. 2) and nine are characterized by a trichodermium (*L. alopochroa, L. castanea, L. citrophylla, L. erythrosticta, L. griseovirens, L. infelix, L. papillata, L. poliochloodes*, *L.* sp. 1). New to science are *Lepiota aureofulvella* (close to *L. boudieri*) and *L. papillata*, which is characterized by small basidiomata covered with gray-brown to olive brown squamules, an orange-white to brownish-orange context, spurred basidiospores with straight or outgrown base, clavate to cylindrical cheilocystidia, and a trichodermal pileus covering. A key to *Lepiota* sect. *Stenosporae* in northern Thailand is provided.

Key words — *Agaricaceae,* biodiversity, taxonomy, saprotroph

Introduction

Members of the genus *Lepiota* (Pers.) Gray (*Agaricaceae*) are in general saprotrophic forest floor dwellers (Singer 1986, Vellinga 2004b). They occur worldwide in tropical and temperate regions, with only a few species reported from desert and arctic-alpine areas (Vellinga 2004b). Sequence analyses of nrITS and LSU data in the *Agaricaceae* have shown that *Lepiota* forms a monophyletic clade together with *Cystolepiota, Echinoderma, Melanophyllum,* and *Pulverolepiota* (Vellinga 2003ab, 2004a).

Lepiota was traditionally divided on morphological grounds into sections based on spore shape and (secondarily) pileus covering structure. Section *Stenosporae* (J.E. Lange) Kühner, typified by *L. pseudofelina* J.E. Lange, is characterized by spores with a distinct outgrowth (spur) at the base, and a trichodermal or cutis-like pileus covering (e.g., Singer 1986, Bon 1993). Molecular-phylogenetic analyses have since reorganized the morphologically defined sections (Vellinga 2003b). Vellinga (2003b) noted that species with spurred spores and a hymenidermal pileus covering have been found to relate closely to species with ellipsoid spores and a hymenidermal pileus covering, while species with spores that lack a distinct spur, are slender, and have a trichoderm (e.g., *L. cortinarius* J.E. Lange) group with species with fusiform spores. Vellinga (2003b) also reported that species with ellipsoid spores and a trichoderm without basal short elements form a monophyletic clade with *Lepiota* sect. *Stenosporae,* but that three subclades can be recognized — two with spurred spores plus one with ellipsoid spores. Here we focus on the two spurred-spored clades.

Among the few *Lepiota* species previously reported from Thailand are *L. clypeolaria* (Bull.) P. Kumm., *L. cortinarius*, *L. cristata* (Bolton) P. Kumm., and *L. pseudohelveola* Hora (Soytong 1994, Chandrasrikul 1996, Chandrasrikul et al. 2008), none of which belongs to *Lepiota* sect. *Stenosporae*. However, the following species in *Lepiota* sect. *Stenosporae* are known from other parts of tropical Asia: *L. alopochroa*, *L. citrophylla*, *L. erythrosticta*, *L. leontoderes* (Berk. & Broome) Sacc., and *L. pyrrhaes* (Berk. & Broome) Sacc. from Sri Lanka (Pegler 1972, 1986; Petch & Bisby 1950); *L. castanea*, *L. erythrosticta*, and *L. griseovirens* from southern India (Kumar & Manimohan 2009); and *L. aurora* E. Horak, *L. castanea*, *L. crepusculata* E. Horak, *L. erythrosticta*, *L. infelix*, *L. luteocastanea* E. Horak, and *L. squamatula* E. Horak from Papua New Guinea (Horak 1981).

Lepiotaceous fungi have been studied in East Asia in recent years (Ge & Yang 2006; Ge et al. 2010; Liang et al. 2009, 2010b; Vellinga et al. 2011). The present study focuses on *Lepiota* sect. *Stenosporae* in northern Thailand, as part of our ongoing efforts to document the diversity of *Agaricaceae* from this area (Zhao et al. 2010, Vellinga et al. 2011). We used morphological and molecular methods to identify and circumscribe our taxa.

Materials & methods

Collecting and examination methods

Collecting sites in Chiang Mai and Chiang Rai provinces, Thailand, were surveyed during the rainy seasons from April to October, 2007–2010. The sites, located within the coordinates 16°06.16′N 98°29.64′E and 19°48.60′N 99°54.60′E at altitudes of 596–1700 m, comprise different vegetation types. Detailed notes, concerning location, vegetation type, soil and substrate were taken in the field. Most specimens were also photographed in the field. All material is deposited in the herbarium of Mae Fah Luang University

(MFLU). Macromorphological characters were noted in the laboratory based on the fresh materials, using standard procedures and terms (Vellinga & Noordeloos 2001). Color annotations in the macroscopical descriptions are from Kornerup & Wanscher (1978), or if preceded by 'Mu.' from Munsell (1975). Microscopical characters were studied from dry specimens and drawn using a drawing tube attached to an Olympus CX-41research compound microscope. Characters were observed in Congo red in ammonia, water, or in 2.5–10% of KOH. Chemical reactions in Melzer's reagent, Cotton blue and Cresyl blue were noted. At least 20 spores per collection were measured in side view. The notation [180,7,6] indicates that measurements were made on 180 spores in seven samples in six collections. The following abbreviations are used: 'L' for lamellae, 'l' for lamellulae, 'avl' for average length, 'avw' for average width, 'Q' for quotient of length and width and 'avQ' for average quotient.

Molecular and phylogenetic methods

DNA extraction—DNA was extracted from herbarium collections (Table 1) according to the instructions of the Biospin Fungus Genomic DNA Extraction Kit (Bioer Technology Co., Ltd., Hangzhou, P.R. China).

Table 1. *Lepiota* species for the ITS sequences used in the phylogenetic analyses in this study.

Species	Country	Collection & Herbarium	ITS GenBank accession number
L. alopochroa	Thailand	MFLU090178 (MFLU)	HQ647294***
L. andegavensis	France	P.D.H. Roux 2121 (herb. Roux)	AY176461*
L. aureofulvella	Thailand	MFLU090183	HQ647293***
L. boudieri	The Netherlands	E.C. Vellinga 1180 (L)	AF391025*
	Italy	MCVE: 474	FJ998388*
L. cf. *boudieri*	U.S.A	E.C. Vellinga 2601 (UC)	AY176479**
L. castanea	The Netherlands	N.J. Dam 97020 (herb. Dam)	AY176463*
	The Netherlands	H.A. Huijser (herb. Huijser)	AF391026*
L. cingulum	Germany	M. Enderle (L)	AY176359*
L. citrophylla	Thailand	MFLU090172	HQ647295***
L. cristata	U.S.A	P.B. Matheny 1958 (WTU)	AF391051**
L. grangei	Belgium	H.A. Huijser (herb. Huijser)	AY176471*
	Italy	MCVE:4666	FJ998399*
L. griseovirens	Italy	MCVE:13747	FJ998403*
L. ignicolor	The Netherlands	H.A. Huijser (herb. Huijser)	AY176472*
L. cf. *ignipes*	Italy	MCVE: 480	FJ998390**
L. pilodes	The Netherlands	H.A. Huijser (herb. Huijser)	AY176476*
	U.S.A	E.C. Vellinga 3234 (UC)	EF080865**
L. poliochloodes	Thailand	MFLU081272	HQ647296***
L. pseudofelina	Italy	MCVE: 3553	FJ998398*
L. rhodophylla	U.S.A	E.C. Vellinga 2610 (UC)	AY176480**
	U.S.A	E.C. Vellinga 3026 (UC)	EF080864**
L. subalba	The Netherlands	E.C. Vellinga 2242 (L)	AY176489*
L. tomentella	The Netherlands	H.A.Huijser (L)	EF080868*
Lepiota sp.	Thailand	E.C. Vellinga 3881 (MFLU)	HQ647297***
	U.S.A	E.C. Vellinga 3327 (UC)	EF080867**
	U.S.A	E.C. Vellinga 2574 (UC)	AY176484**
	U.S.A	E.C. Vellinga 2603 (UCB)	AY176481**
	U.S.A	E.C. Vellinga 3014 (UC)	EF080866**

* = sequence from Europe, ** = sequence from U.S.A, *** = new sequence from Thailand

PCR and sequencing—Primers ITS1-F, ITS 1, and ITS4 were used for the nrITS1, 5.8S and nrITS2 regions, and PCR conditions followed Gardes & Bruns (1993). PCR amplified products were cleaned up by Shanghai Sangon Biological Engineering Technology & Services Co. Ltd.). Sequencing was performed using Big Dye chemistry, with the same primers as for PCR, and an ABI PRISM 3100 Genetic Analyzer (both from Applied Biosystems, Foster City, CA, USA). All new sequences were deposited in GenBank.

Data analysis—Sequences were edited and contigs assembled using Sequencher 4.2.2 (Gene Codes Corporation, Ann Arbor, MI, USA). The sequences of all taxa belonging to *Lepiota* sect. *Stenosporae* present in GenBank were downloaded, and the complete data set aligned using MAFFT (Katoh et al. 2002, Katoh & Toh 2008) and minimally manually adjusted. Heuristic search of ITS was performed using the maximum parsimony (MP) option of the program PAUP* 4.0 b10 (Swofford 2004), using 1000 heuristic searches, employing TBR branch swapping and random sequence addition. Other setting were as follows: gaps were treated as missing data; all characters are of type unordered and equally weighted; multistate taxa interpreted as uncertainty; starting trees were obtained via stepwise addition; one tree was held at each step during stepwise addition; the steepest descent option was not in effect, branches were collapsed (creating polytomies) if minimum branch length was zero, and MulTrees option was in effect. Bootstrap supports were evaluated using 1000 bootstrap replicates with 10 heuristic searches per replicate, random sequence addition and TBR branch swapping. A Maximum Likelihood analysis was performed with the on line program RAxML (Stamatakis et al. 2008). All free model parameters were estimated by RAxML using a general time-reversible (GTR) substitution matrix and a proportion of invariable sites estimate. One hundred rapid ML bootstraps were performed. The ML tree was visualized with the program Figtree v. 1.3.1 (Rambaut 2009).

Results

Nine named and two unnamed species of *Lepiota* sect. *Stenosporae* were recognized in this study. A key to the eleven taxa is provided and each taxon is provided with a full description, colored photographs (Figure 1), and illustrations. Table 2 summarizes the morphological characters of the Thai species. Two species (*L. aureofulvella, L.* sp. 2) have a cutis pileus covering and most (except *L. papillata*) have dextrinoid spores.

ITS sequence data for five species from Thailand were compared with those from 23 European and U.S.A. specimens; *Lepiota cristata* with spurred spores and a hymeniform pileus covering is used as outgroup (Table 1). The topology of a tree based on Maximum Likelihood analysis is identical to the one presented here (Figure 2) and two clades are present in the tree. Clade 1 comprises species with spurred spores and a trichodermal pileus covering; the Thai species *L. citrophylla* and *L. poliochloodes* group together and are sister to *L. grangei, L. griseovirens,* and *L. pseudofelina* from Europe with low bootstrap support; *L. alopochroa* groups with *L. castanea* and forms a clade with *L.* cf. *ignipes* (from North America) with high bootstrap support. Clade 2, comprising species

Figure 1. Basidiomata of species of *Lepiota* section *Stenosporae* in the field: a. *L. aureofulvella;* b. *L. citrophylla;* c. *L. castanea;* d. *L. alopochroa;* e. *L. poliochloodes;* f. *L. infelix;* g. *L. papillata;* h. *L.* sp. 2; i. *L. griseovirens;* j. *L. erythrosticta;* k. *L.* sp.1.

with spurred spores and a cutis-like pileus covering, includes *L. andegavensis* and *L. boudieri* (Europe), *L.* cf. *boudieri* and *L. rhodophylla* (U.S.A.), and *L. aureofulvella* (Thailand); *L. aureofulvella* groups with *L. boudieri* with low bootstrap support (Figure 2).

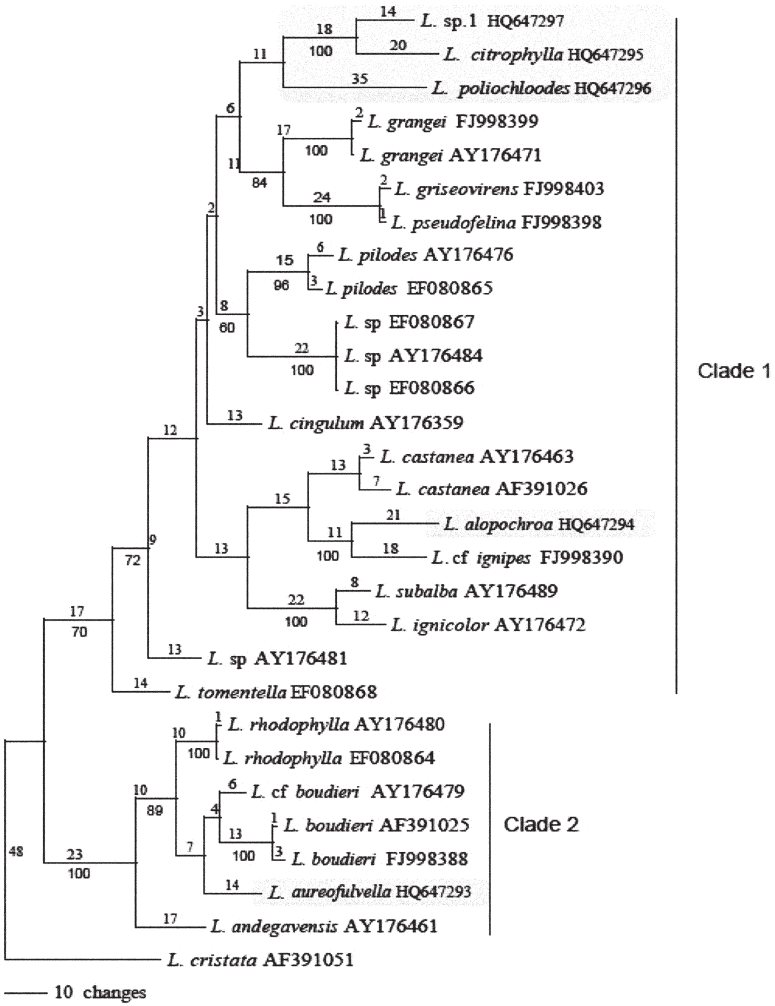

Figure 2. Phylogenetic relationships of *Lepiota* section *Stenosporae* based on a Maximum Parsimony analysis of nrITS sequences. Bootstrap values ≥60 % are indicated below the branches. GenBank accession numbers are given for each collection. The topology of a tree based on Maximum Likelihood analysis is identical. Two clades are present in the tree, clade 1 is composed of species with spurred spores and a trichodermal pileus covering; clade 2 is composed of species with spurred spores and a cutis-like pileus covering. *Lepiota cristata* with spurred spores and a hymeniform pileus covering is used as outgroup.

Table 2. Selected *Lepiota* basidiospore and pileus covering structure characters in collections from Thailand.*

Species	Spore size (µm)	avl × avw	Q	avQ	dext[1]	pc[2]
L. alopochroa	7.5–9.3 × 3.8–4.0	8.5 × 3.9	2.0–2.3	2.2	+	Trichoderm
L. aureofulva	5.8–7.5 × 3.0–4.8	7.2 × 3.8	1.6–2.1	1.9	+	Cutis
L. castanea	9.5–13.0 × 3.8–5.2	11.5 × 4.5	2.4–2.6	2.5	+	Trichoderm
L. citrophylla	6.0–8.5 × 3.8–4.3	7.2 × 4.0	1.5–2.0	1.8	+	Trichoderm
L. erythrosticta	7.8–11.3 × 3.8–4.8	9.8 × 4.2	2.2–2.8	2.3	+	Trichoderm
L. griseovirens	6.2–7.0 × 3.5–4.2	6.7 × 3.8	1.5–1.8	1.7	+	Trichoderm
L. infelix	7.5–9.0 × 4.0–4.2	8.3 × 4.0	1.7–2.2	2.0	+	Trichoderm
L. papillata	7.2–11.8 × 4.0–4.8	8.2 × 4.1	1.8–2.5	2.0	–	Trichoderm
L. poliochloodes	6.5–8.2 × 3.0–3.8	7.2 × 3.5	1.6–2.4	2.0	+	Trichoderm
Lepiota sp. 1	7.1–8.4 × 2.8–4.2	7.8 × 3.2	1.9–2.8	2.4	+	Trichoderm
Lepiota sp. 2	6.2–8.0 × 3.2–4.0	7.3 × 3.7	1.6–2.5	1.9	+	Cutis

* No taxa have metachromatic basidiospores; all have cheilocystidia.
[1] dext = dextrinoid, [2] pc = pileus covering.

Taxonomy

Key to species of *Lepiota* section *Stenosporae* identified in this study

1. Pileus covering a cutis made up of cylindrical elements 2
1. Pileus covering a trichoderm made up of erect cylindrical to narrowly clavate elements. 3
2. Pileus covering yellowish brown, golden-brown to brown; pileus covering elements cylindrical, septate and not branched . . . . . *L. aureofulvella*
2. Pileus covering grayish yellow, grayish brown, or slightly reddish brown; pileus covering elements cylindrical, septate and sometimes branched . . . *L.* sp. 2
3. Basidiomata pale yellow to light yellow . . . . . *L. citrophylla*
3. Basidiomata not yellow 4
4. Basidiomata pinkish; pileus with reddish white to pinkish squamules. . . *L. erythrosticta*
4. Basidiomata not pinkish; pileus without reddish white to pinkish squamules, but with gray, brown, greenish to dark colors. 5
5. Pileus covered with gray to grayish brown, dark gray or olive brown squamules 6
5. Pileus covered with brown to dark brown or reddish brown squamules 8
6. Pileus umbonate with high umbo or papilla, covered with brownish gray to olive brown squamules. . . . . *L. papillata*
6. Pileus umbonate with wide umbo, covered with gray to grayish brown, sometimes olivaceous squamules 7
7. Pileus with gray to grayish brown small plush-like squamules or floccules; smell mild; basidiospores 6.5–8.2 × 3.0–3.8 µm. . . . . *L. poliochloodes*
7. Pileus with small plush-like squamules or floccules, grayish brown to black, sometimes with a hue of green to olive-brown; smell fruity; basidiospores 6.2–7.0 × 3.5–4.2 µm . . . . . *L. griseovirens*

8. Pileus covered with reddish brown small scales or squamules. . . . . *L.* sp. 1
8. Pileus covered with light brown to dark brown squamules. 9

9. Pileus convex without or with low umbo. . . . . *L. infelix*
9. Pileus umbonate or with distinct umbo. 10

10. Pileus covered with dark brown to dark at center (umbo), with brown squamules around center toward margin; smell spicy; basidiospores 9.5–13 × 3.8–5.2 µm . . . . . *L. castanea*
10. Pileus umbonate, covered with brown squamules toward margin; smell fruity; basidiospores 7.5–9.3 × 3.8–4.0 µm . . . . . *L. alopochroa*

Lepiota alopochroa (Berk. & Broome) Sacc., Syll. Fung. 5: 63. 1887. Fig. 3

≡ *Agaricus alopochrous* Berk. & Broome, J. Linn. Soc., Bot. 11: 510. 1871.

≡ *Lepiotula alopochroa* (Berk. & Broome) E. Horak, N.Z. J. Bot. 18: 185. 1980.

Pileus 14 mm, umbonate, expanding to plano-concave with low umbo, with inflexed margin, brown (7E6–7) at umbo, rough or with crowded squamules, with surface breaking up around umbo, with brown (7E6–7) fibrillose squamules toward margin, on light brown (6D5–6) fibrillose background, with peeling surface at margin and white background, with white fibrillose remnants of partial veil and margin exceeding lamellae. Lamellae free, crowded, ventricose, 1 mm wide, white or pale yellow to orange-white (4A3, 5A2), with white serrulate edge. Stipe 35 × 2.5–4 mm, cylindrical or slightly tapering to apex and wider at base, with grayish orange to brownish orange (5B4–5, 6C5) background, white fibrillose at annular zone, with brown (7E6–7) squamules or fibrillose squamules at middle zone downward base, with white rhizomorphs at base, hollow. Annulus as an annular zone. Context in pileus white, 0.5 mm wide; in stipe concolorous with surface. Smell fruity. Taste unknown. Spore print white.

Basidiospores [25,1,1] 7.5–9.3 × 3.8–4.0 µm, avl × avw = 8.5 × 3.9 µm, Q = 2.0–2.3, avQ = 2.2, in side view oblong to cylindrical, spurred, truncate or with outgrown base, with acute apex, in frontal view fusiform to oblong, thick-walled, hyaline, dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl blue. Basidia 13–17 × 6.0–8.0 µm, clavate, narrowly clavate, rarely subclavate, 4-spored, thick-walled, hyaline. Lamella edge sterile. Cheilocystidia 25–37 × 5–7 µm, narrowly clavate to cylindrical, with rounded apex, rarely utriform, thin-walled, hyaline. Pleurocystidia absent. Pileus covering a trichoderm made up of narrowly clavate to cylindrical elements, 50–113 × 3.5–18 µm, brown and thick-walled, with parietal pale brown pigment; underlayer with hyaline to pale brown hyphae, 2.5–4 µm wide. Clamp connections present in all tissues.

Habitat and distribution—Solitary, saprotrophic and terrestrial on soil, on dead leaves in bamboo forest. Known from one locality in northern Thailand.

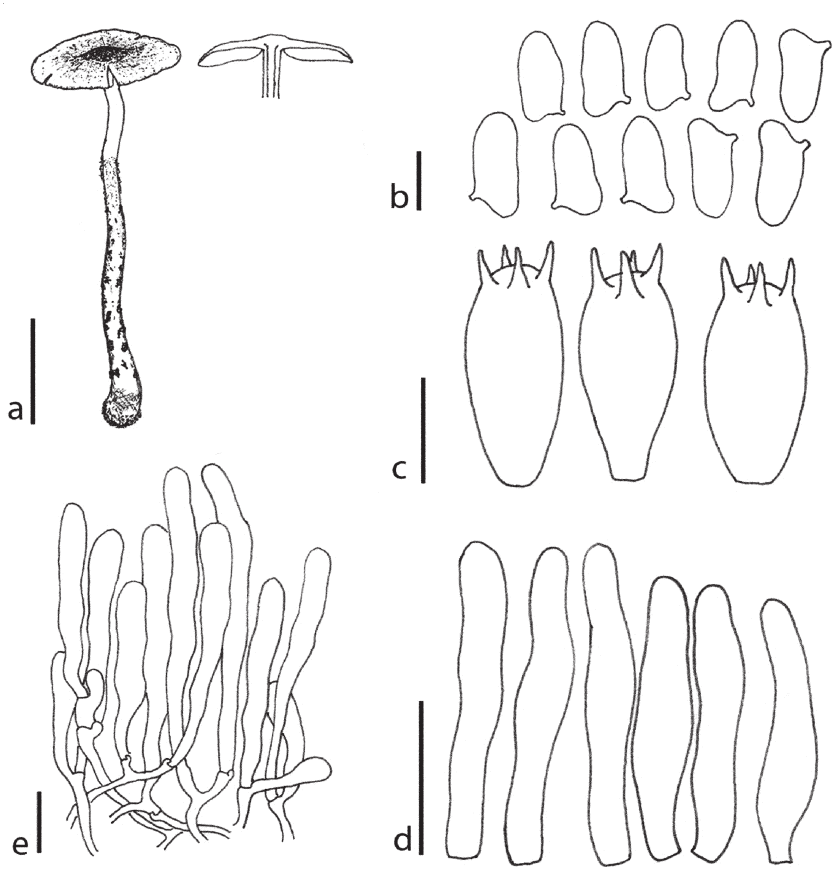

Figure 3. *Lepiota alopochroa* (MFLU090178).
a. basidiomata; b. basidiospores; c. basidia; d. cheilocystidia; e. pileus covering.
Scale bars: a = 10 mm; b–d = 10 μm; e = 20 μm.

Material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Taeng Distr., Mok Fah Waterfall, 20°02′43.1″N, 99°52′35.0″E, 596 m alt., 6.VIII.2008, P. Sysouphanthong, MFLU090178.

Discussion—As a representative of the *Lepiota castanea* group, *L. alopochroa* is characterized by relatively short spores (averaging 8.5 × 3.9 μm) and relatively short elements in the pileus covering; the cheilocystidia are narrowly clavate to cylindrical. Despite these short spores and short pileus covering elements it differs from *L. ignicolor* Bres. in nrITS sequences (Figure 2). The Thai collections of *L. castanea* have darker basidiomata, longer spores, and longer elements in the pileus covering.

Although the collection reasonably well fits *L. alopochroa* as described by Pegler (1972, 1986) and Horak (1980, as *Lepiotula alopochroa*), there are no available molecular data to support this conclusion.

Lepiota aureofulvella Sysouphanthong, K. D. Hyde, Chukeatirote & Vellinga, **sp. nov.** Fig. 4

Mycobank MB 519671

Pileus 15–40 mm, convexus vel campanulatus, umbonatus, plano-concavus, fibrillosus, flavidus-brunneus vel auratus. Lamellae liberae, albae vel pallide luteae, 5-6 mm. Stipes 25–45 × 2.5–5 mm, cylindricus vel subclavatus, fibrillosus, albus dein laete brunneus. Basidiosporae 5.8–7.5 × 3.0–4.8 µm, calcaratae. Basidia 16. –21.5 × 5.5–6.3 µm, clavata. Cheilocystidia 17.5–27.5 × 5–10 µm, clavata, anguste clavata. Epicutis ex cellulis cylindraceis vel anguste clavatis. Fibulae adsunt.

Holotypus: Thailand, Chiang Mai Prov., Mae Taeng Distr., Mok Fah Waterfall National Park, 20°02′43.1″N, 99°52′35.0″E, 596 m. alt., 8.VIII.2008, P. Sysouphanthong PS110 (MFLU090183, **holotype**).

Etymology: '*aureofulvella*' means golden-brown and refers to a close relationship with *L. boudieri* (syn. *L. fulvella* Rea)

Pileus 15–40 mm, convex to umbonate, expanding to plane or plano-concave, with straight margin, with crowded brown (6E7–8) fibrils at umbo, with concentrically crowded fibrillose squamules from umbo toward margin, yellowish brown to golden brown (5D5–7), on white background, when mature surface peeling from background; margin fringed and exceeding lamellae. Lamellae free, crowded, ventricose, 5–6 mm wide, white, with white serrulate edge. Stipe 25–45 × 2.5–5 mm, cylindrical to subclavate, with white to light brown (6D4–5) background, white fibrillose in upper zone, at base with slightly brown (6E4–8) fibrillose squamules, with white rhizomorphs at base, hollow. Annulus an annular zone, with white fibrils. Context in pileus white and 4.5–5 mm wide; in stipe concolorous with surface. Smell fruity. Taste unknown. Spore print white.

Basidiospores [60,3,3] 5.8–7.5 × 3.0–4.8 µm, avl × avw = 7.2 × 3.8 µm, Q = 1.6–2.1, Qav = 1.9, cylindrical to oblong, with truncate to spurred base, triangular or with curved abaxial side, in frontal view cylindrical, thick-walled, hyaline, dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl blue. Basidia 16.3–21.5 × 5.5–6.3 µm, clavate, slightly thick-walled, 4-spored. Lamella edge sterile. Cheilocystidia 17.5–27.5 × 5–10 µm, clavate, narrowly clavate, utriform, cylindrical, hyaline, slightly thick-walled. Pleurocystidia absent. Pileus covering a cutis made up of cylindrical elements, sometimes with narrowly clavate terminal elements, 40–130 × 5.5–14 µm, thick-walled, with brown parietal pigment; underlayer with hyaline to pale brown hyphae, 3–4 septate, 5.0–13 µm wide. Clamp connections present in all tissues.

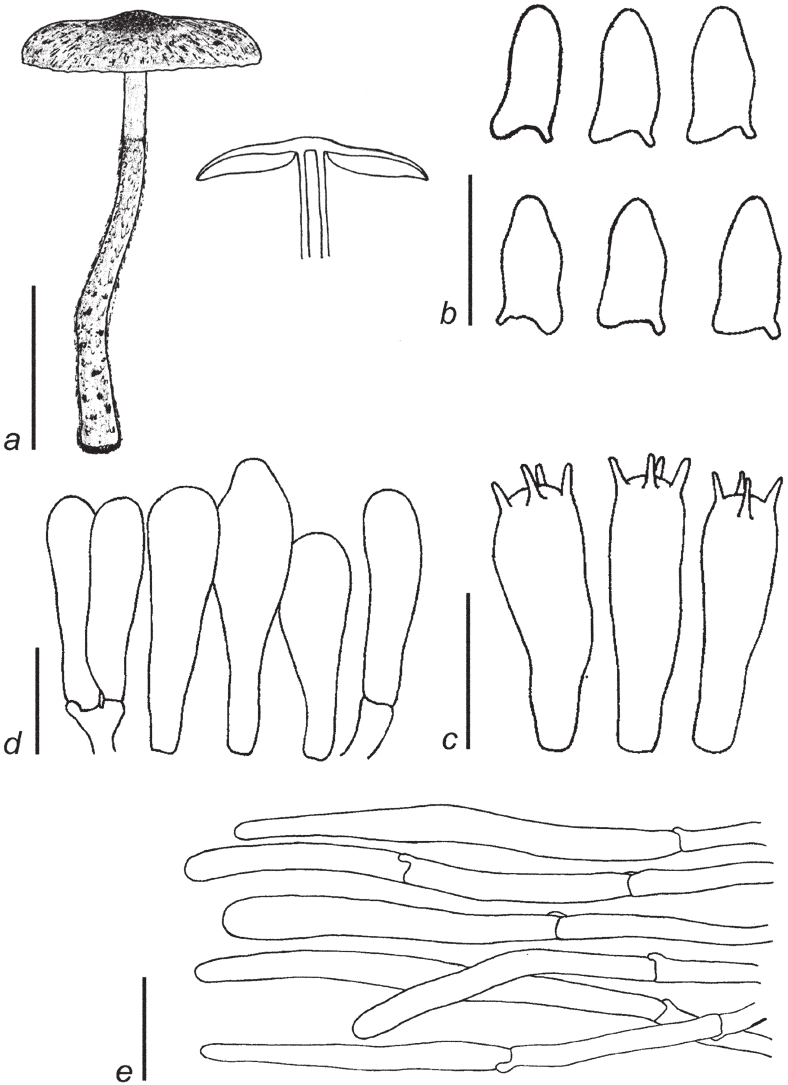

Figure 4. *Lepiota aureofulvella* (MFLU090183).
a. basidioma and a section; b. basidiospores; c. basidia;
d. cheilocystidia; e. elements of pileus covering.
Scale bars: a = 10 mm, b–e =10 μm.

Habitat and distribution—growing in a small to large group; saprotrophic on decayed wood, soil rich in humus, and found in forest with dominant bamboo; in one locality in northern Thailand.

Additional material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Taeng Distr., Mok Fah Waterfall National Park, 20°02′43.1″N, 99°52′35.0″E, 596 m. alt., 24.VI.2010, P. Sysouphanthong, MFLU100592; ibidem, 9.VI.2010, P. Sysouphanthong, MFLU100621.

Discussion—*Lepiota aureofulvella* is characterized by the yellowish brown or light brown to golden brown color of the pileus covering, clavate to utriform cheilocystidia, and cutis-like pileus covering.

The only similar species, *L. alopochroa,* resembles *L. aureofulvella* in color and general stature but differs in the trichodermal pileus covering.

Lepiota squamatula from Papua New Guinea, which is discussed and illustrated as having a cutis-like pileus covering but diagnosed in Latin as having a trichoderm, differs in having orange-brown squamules and fibrils on the pileus, longer (8.0–9.0 μm) and narrower (2.5–3.5 μm) basidiospores, and a pileus covering "composed of cylindric interwoven hyphae forming a cutis or trichoderm" (Horak 1980).

Some north temperate species with a cutis-like pileus covering and spurred basidiospores are similar to *L. aureofulvella. Lepiota boudieri* Bres. is similar in morphology but has somewhat darker and less golden colors and shorter (5.8–7.5 μm) basidiospores (Vellinga 2001); the western North American *L. rhodophylla* Vellinga is distinguished by a pinkish-brownish pileus covering with a pinkish brown margin and pink to pale brownish lamellae (Vellinga 2006); and the French species, *L. andegavensis* Mornand (Mornand 1983), has very dark pileus colors.

The nrITS based phylogeny (Figure 2) clearly separates *L. aureofulvella* from all the other species in clade 2 with a cutis-like pileus covering and for which sequence data are available.

Lepiota castanea Quél., C.r. Ass. Franç. Av. Sci. (Reims 1880) 9: 661. 1881. Fig. 5

Pileus 15–20 mm, umbonate to campanulate with wide umbo, with inflexed margin, with crowded fibrils at umbo, brown (7E6–8) and changing to dark brown to dark when dry (7F6–8), with rough umbo, with rough surface around umbo to margin, brown (6E5–6) and paler at margin (6D5–7), with surface soon breaking up and becoming squamules or patch-like squames with upcurved tips, on white background, at margin white fibrillose and with light brown fibrillose squamules. Lamellae free, crowded, ventricose, 3 mm wide, white, with smooth edge. Stipe 40–58 × 1.8–3 mm, cylindrical or slightly tapering to apex, white from apex to 1/3 of length, white or pale orange to light orange from annular zone to base with squamule-like, light brown to brown (6D5–7, 6E6) patches and bands, hollow, with white rhizomorphs at base. Annulus an annular zone, with squamules or fibrillose partial veil. Context in pileus white and dull, 2–2.5 mm wide, in stipe white. Smell spicy. Taste unknown. Spore print white.

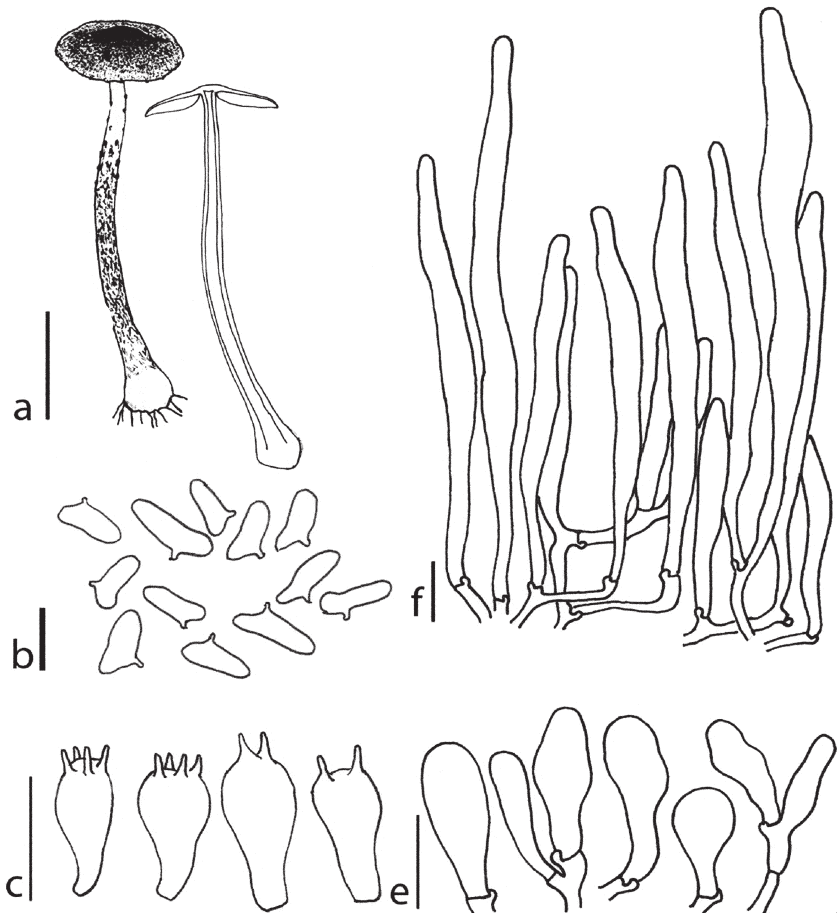

Figure 5. *Lepiota castanea* (MFLU090106).
a. basidioma and a section; b. basidiospores; c. basidia; d. cheilocystidia; e. pileus covering.
Scale bars: a = 10 mm; b–e = 10 μm..

Basidiospores [75,2,2] in side view 9.5–13 × 3.8–5.2 μm, avl × avw = 11.5 × 4.5 μm, Q = 2.4–2.6, Qav = 2.5, in side view cylindrical, with truncate to distinctly spurred base, mostly with outgrown broad basal spur and long hilar appendage, some with a straight base, in frontal view oblong to cylindrical, hyaline, slightly thick-walled, dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl blue. Basidia 18–23 × 9.0–10 μm, clavate, 4-spored, with or without mucilaginous contents. Lamella edge sterile. Cheilocystidia

18–36 × 5.5–12.5 µm, usually clavate to narrowly clavate, with acute or rounded apex, often utriform, thin-walled. Pleurocystidia absent. Pileus covering and stipe covering a trichoderm made up of narrowly clavate to cylindrical elements, wider at middle and narrowing to apex and base, 40–375 × 6.5–35 µm, with slightly thickened walls, pale brown to brown-walled, with parietal brown pigment, with rare short clavate elements; under layer with cylindrical hyphae, hyaline to pale brown-walled, 2.5–5 µm wide. Clamp connections present in all tissues.

Habitat and distribution—growing solitary or in a small group, saprotrophic and terrestrial on forest floor with high amount of humus, only found in deciduous forest at high elevation (Doi Inthanon National Park, Chiang Mai Province, Thailand). Widely distributed in Europe and North America and temperate parts of Asia (Vellinga 2001), also recorded from India and Nepal (Manandhar & Adhikari 1994), and from Papua New Guinea (Horak 1981). This is a new record for Thailand.

Material examined: **THAILAND, Chiang Mai Prov.**, Chom Thong Distr., Doi Inthanon National Park, Junction of Highway 1009 and Road to Mae Cheam, 19°31.58′N, 98°29.64′E, 1700 m alt., 20.VI.2008, P. Sysouphanthong MFLU090106; 15.VII.2008, P. Sysouphanthong, MFLU090154.

Discussion—The *L. castanea* complex is in need of a combined morphological-molecular approach to resolve the species borders. Vellinga (2001), who took a pragmatic view, considered *L. castanea* a very variable species, variable in terms of spore length and length of pileus covering elements. Migliozzi & Zecchin (1997, 2000) recognized several species in the complex: *L. rufidula* Bres. for the long-spored taxon, commonly (also by us) named *L. castanea*; *L. ignipes* Bon is considered a synonym of *L. rufidula*; *L. castanea* s. str. for one short-spored species and *L. ignicolor* for a taxon with small basidiomata and spores tending toward ovoid. A collection referred to *L. ignicolor* is sister to *L. subalba* P.D. Orton in the phylogenetic analyses based on nrITS sequences (Figure 2); *L. subalba* has short elements in the pileus covering but whitish basidiomata. The characters of the Italian collection named *L. ignipes* in GenBank (accession number FJ998390) are not known, but the molecular data indicates that it differs from the other taxa in this complex.

Lepiota cingulum Kelderman, which resembles *L. castanea*, has predominantly pinkish brown basidiomata and a pileus covering with terminal elements that tend to taper towards the tips (Kelderman 1994).

The record of *L. castanea* from Nepal (Manandhar & Adhikari 1994–95) probably refers to another species, as the spores are described as ellipsoid.

Lepiota castanea is rare in northern Thailand and was found only at one locality at 1700 m asl on Thailand's highest mountain early in the rainy season. It represents the temperate Eurasian element of the Thai *Lepiota* mycota.

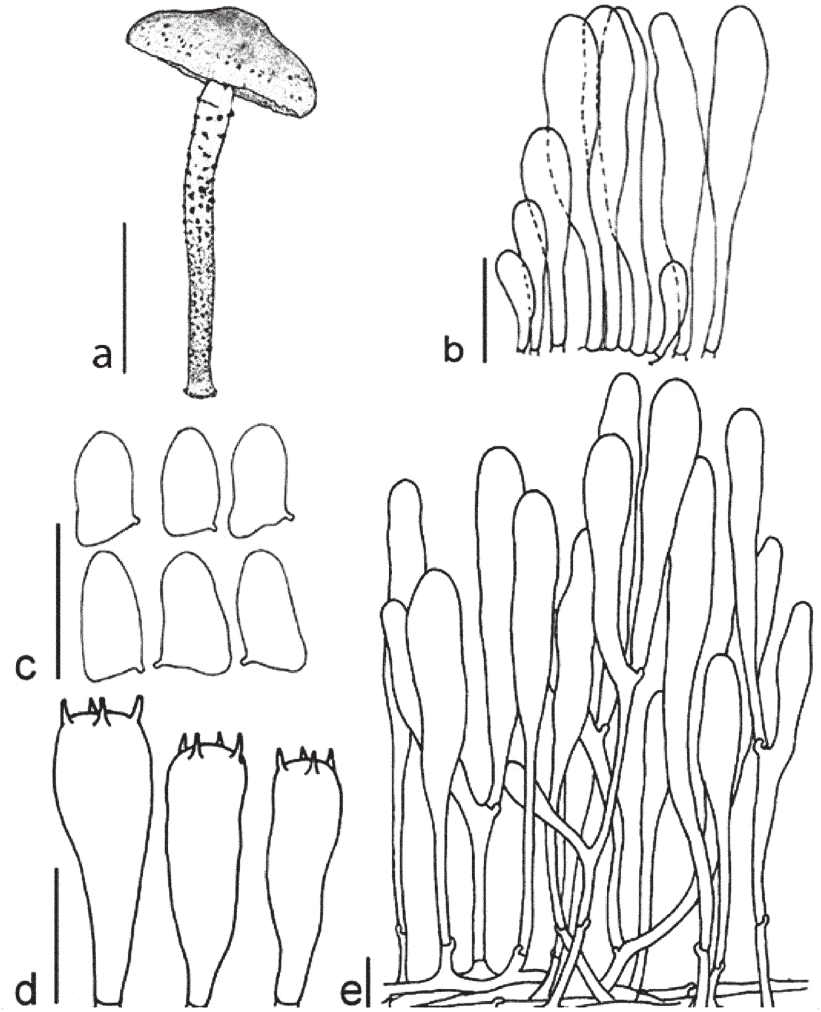

Figure 6. *Lepiota citrophylla* (MFLU090101).
a. basidiomata; b. cheilocystidia; c. basidiospores; d. basidia; e. pileus and stipe covering.
Scale bars a = 10 mm; b–e = 10 μm.

Lepiota citrophylla (Berk. & Broome) Sacc., Syll. Fung. 5: 57. 1887. Fig. 6

≡ *Agaricus citrophyllus* Berk. & Broome, J. Linn. Soc., Bot. 11: 509. 1871.

Excluded: *Lepiota citrophylla* sensu Rea (1922), Akers & Sundberg (1998), Liang et al. (2010a).

Pileus 15–35 mm, subglobose to conical, expanding to campanulate, with moderately wide umbo, with inflexed margin, at umbo covered with fine

squamules to floccules, brown (6D7) at umbo and with light brown to yellowish brown (5D6–8) squamules toward margin on pale yellow to light yellow (4A3–4) background; margin with distant squamules, sometimes with partial veil. Lamellae free, crowded, ventricose, 2.5–3.8 mm wide, pale yellow to light yellow (3A4–4A4), with concolorous serrulate edge. Stipe 60–65 × 2–3 mm, cylindrical, slightly wider at annular zone; surface covered with squamules from annular zone to middle and with small light brown to brown (5D6–6D7) squamules at middle to base, on light yellow (4D4) background; hollow. Annulus an annular zone or made up of squamules. Context in pileus 1.8–2 mm wide and pale yellow (3A3), in stipe light yellow (4D4). Smell as burnt rubber. Taste unknown. Spore print white.

Basidiospores [100, 5, 5] in side view 6.0–8.5 × 3.8–4.3 µm, avl × avw = 7.2 × 4.0 µm, Q = 1.5–2.0, avQ = 1.8, in side view with straight or outgrown spur at base, ellipsoidal to cylindrical with rounded or more acute apex, in frontal view oval, cylindrical, hyaline, thick-walled, strongly dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl Blue. Basidia 19–37 × 6.5–8.5 µm, clavate to slightly narrowly clavate, 4-spored, hyaline, with thin wall. Lamella edge sterile. Cheilocystidia 15–60 × 5.0–10 µm, narrowly clavate, sometimes clavate, utriform, rarely narrowly fusiform, or wider at center. Pleurocystidia absent. Pileus covering a trichoderm made up of erect narrowly clavate elements, often narrowed into pedicel, 50–160 × 8.5–17 µm, with thin brown wall, with parietal and intracellular brown pigment, with an under layer of cylindrical hyphae, 2–6.5 µm wide, with thin hyaline to slightly pale brown walls, with intracellular pigment. Stipe covering with same structure as pileus covering. Clamp connections present in all tissues.

Habitat and distribution—solitary or in small groups, terrestrial in soil with decaying leaves and wood, found in deciduous forest and pine forests of northern Thailand. Widely distributed in the tropics: Sri Lanka (Pegler 1972), Trinidad (Dennis 1952), Kenya and East Africa (Pegler 1977), and India (Natarajan & Manjula 1983). This is the first record from Thailand.

Material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Taeng Distr., Hot Spring National Park, 16°06′16.1″N, 99°43′07.9″E, 780–805 m alt., 30.VII.2008, P. Sysouphanthong, MFLU090172; 8.VIII.2010, MFLU090185; Mae Sae Village, 19°07′13.7″N, 98°43′52.9″E, 962 m alt., 14.VI.2008, P. Sysouphanthong, MFLU090101; **Chiang Rai Prov.**, Mae Fa Luang Distr., Doi Tung National Park, 10.VI.2009, P. Sysouphanthong, MFLU100405; Wiang Chiang Rung Distr., Hui Mae Sack Waterfall National Park, 26.VIII.2009, P. Sysouphanthong, MFLU100424.

Discussion—This species is found during the whole rainy season and is widespread in northern Thailand. It is quite variable in basidiome size and pileus covering color. *Lepiota citrophylla* is the only species of sect. *Stenosporae* in northern Thailand characterized by predominantly yellow basidiome colors. The Thai material is very similar to collections from Sri Lanka described by

Pegler (1972, 1986), but he did not recover cheilocystidia in the material from Sri Lanka and his described shorter pileus covering elements are shorter (30–80 × 12–17 µm). There can be two reasons for this: the material he studied is young, or the longer elements were degraded, broken, or otherwise not easily found and measured.

The name *L. citrophylla* has been applied to both a European species (e.g. Rea 1922; Kühner 1934) and an American species (Akers & Sundberg 1998), but those have non-spurred spores; the European species was subsequently described as *L. xanthophylla* P.D. Orton (Orton 1960).

Lepiota luteocastanea is very close to *L. citrophylla* in yellow basidiome colors, but L. *luteocastanea* is distinctly purple tinged on the pileus and has fusoid-cylindric elements in the pileus squamules (Horak 1981). *Lepiota subcitrophylla* Hongo (1956) from Japan also comes close to *L. citrophylla* but turns blue when bruised or damaged. *Verrucospora vulgaris* Pegler, which resembles *L. citrophylla* in the brown squamules, yellow tinged basidiomata, and persistent annulus, does not have free lamellae and produces angular basidiospores (Pegler 1977).

Lepiota citrophylla has previously been known only from tropical parts of Asia and is reported from Thailand here for the first time. A recent report of this species from China refers to a different species representing *Lepiota* sect. *Lepiota*, as the spores are not spurred (Liang et al. 2010a).

Lepiota erythrosticta (Berk. & Broome) Sacc., Syll. Fung. 5: 62. 1887. Fig. 7
≡ *Agaricus erythrostictus* Berk. & Broome, J. Linn. Soc., Bot. 11: 508. 1871.

Pileus 14 mm, parabolic, with straight margin, with crowded reddish or pinkish (8A2–3) squamules at center and toward margin, sometimes with fibrillose squamules, on white to pale red (8A3) background; margin sulcate, with reddish white (8A2–3) fibrillose squamules and partial veil remnants. Lamellae free, slightly crowded, broadly ventricose, white to pale orange (6A3), with white floccose edge. Stipe 32 × 2–2.5 mm, cylindrical, with, 3–3.5 mm wide basal bulb, white (6A2) at apex, covered with light brown to reddish or pinkish (6D4, 8A2) fibrillose squamules on orange fibrillose background from annular zone downward, hollow. Annulus an annular zone, with fibrils and fibrillose squamules similar to those on pileus. Context in pileus white, turning orange white to pale orange (5A2–3), 1 mm wide; in stipe orange white (5A2) in apical zone, grayish red to reddish brown (8C5–8D5) from midway downward. Taste unknown. Smell unknown. Spore print white.

Basidiospores [25,1,1] 7.8–11.3 × 3.8–4.8 µm, on average 9.8 × 4.2 µm, Q = 2.2–2.8, avQ = 2.3, in side-view cylindrical with truncate to spurred base, narrowly triangular, in frontal view cylindrical, thick-walled, hyaline, not dextrinoid, congophilous, cyanophilous, metachromatic in Cresyl blue. Basidia

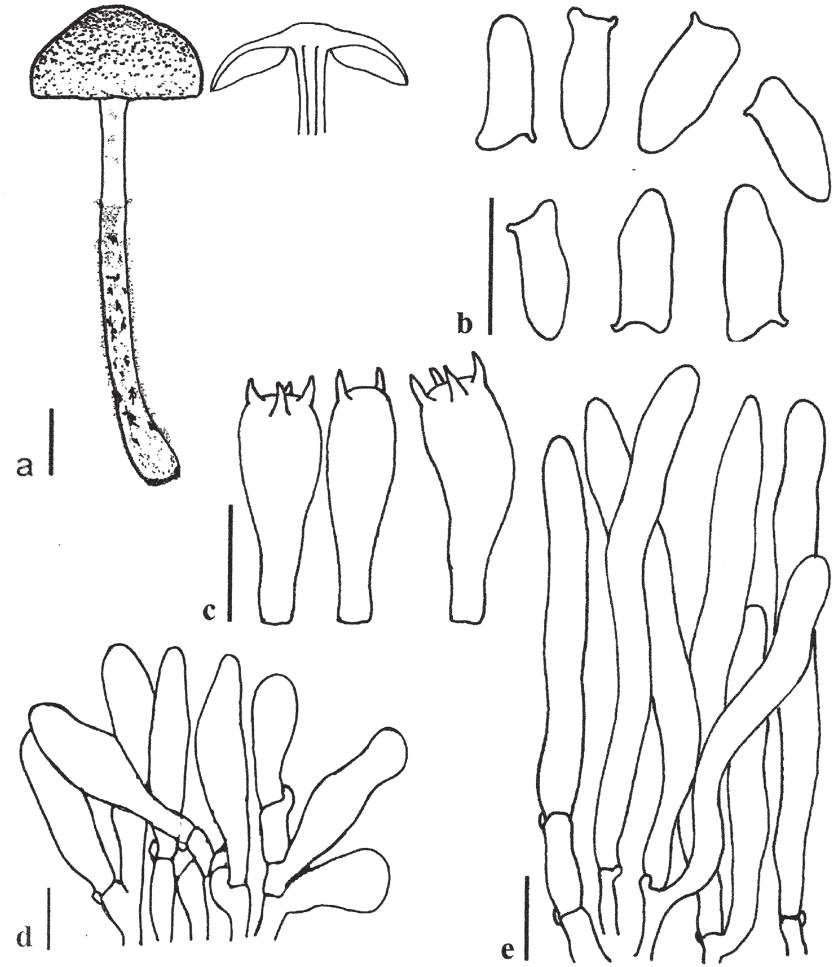

Figure 7. *Lepiota erythrosticta* (MFLU090034).
a. basidioma; b. basidiospores; c. basidia; d. cheilocystidia; e. pileus covering.
Scale bars: a = 1 mm; b–d = 10μm; e = 20 μm.

16–28 × 5–8 μm, clavate, 4-spored, rarely 2-spored. Lamella edge sterile. Cheilocystidia 19–32 × 8–13 μm, irregularly clavate or sphaeropedunculate, utriform, often narrowly fusiform, thick-walled, hyaline. Pleurocystidia absent. Pileus covering a trichoderm made up of long cylindrical elements, 70–170 × 4.5–12.0 μm, hyaline to pale pink-walled, with parietal and intracellular pink pigment, with underlayer made up of hyaline hyphae, 4–10

μm wide. Stipe covering a trichoderm similar to pileus covering. Clamp connections present in all tissues.

Habitat and distribution—Growing solitary, on humus-rich soil with decayed leaves and wood, in forest with dominant bamboo; found in one locality in northern Thailand. Distributed in Sri Lanka (Pegler 1972), Brazil (Wartchow et al. 2008), and Trinidad (Dennis 1952). This is a new record for Thailand.

Material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Taeng Distr., Hot Spring National Park, 16°06′16.1″N, 99°43′07.9″E, 780–805 m alt., 4.VIII.2007, P. Sysouphanthong, MFLU090034.

Discussion—*Lepiota erythrosticta* is recognized by the reddish or pinkish squamules on pileus and stipe and pinkish lamellae. The non-dextrinoid spores and metachromatic reaction of the spore wall in Cresyl blue distinguishes *L. erythrosticta* from all other species in sect. *Stenosporae.*

The sole Thai collection consisted of young basidiomata. Wartchow et al. (2008) recorded longer pileus and stipe covering elements for material from Brazil; Dennis (1952), who recorded this species from Trinidad, noted smaller basidiospores than those found in material from Thailand. Pegler (1972), who studied the Sri Lankan type material but did not report the reaction of spore walls in Cresyl blue, also cited slightly smaller basidiospores. It is possible that the South American reports represent a different taxon.

This species is rare in Thailand; it was only found once (August 2007) in the middle of rainy season at Hot Spring National Park but not the other three years the survey was conducted. Like *L. citrophylla*, *L. erythrosticta* is a species with a tropical distribution pattern.

Lepiota griseovirens Maire, Bull. trimest. Soc. mycol. Fr. 44: 37. 1928. Fig.8

Misapplied name: *Lepiota pseudofelina* sensu Bon (1993), Candusso & Lanzoni (1990).

Excluded: *Lepiota griseovirens* sensu Reid (1972), Bon (1993).

Pileus 8–13 mm, conico-campanulate, expanding to umbonate, plano-convex with broad umbo, with straight margin, at centre covered with tomentose tufts, grayish brown (7F3, 7E3, 7D3) to black, sometimes with a hue of green to olive-brown (4F4–5), toward margin cracked into small squamules, paler than at center, on orange-white to pale orange (5A2–3) background; margin slightly fringed, exceeding lamellae in mature specimen. Lamellae free, slightly crowded, ventricose, and rounded near stipe, 2 mm wide, orange-white to pale orange (5A2), with white eroded to flocculose edge. Stipe 16–20 × 1.5–2.0 mm, with 2.0–2.5 mm wide base, cylindrical, slightly wider at base, white to orange-white (5A2) innately fibrillose above annular zone and below annular zone downward toward base, with scattered grayish brown (7F3, 7E3, 7D3) to black squamules as on pileus, with brownish-orange (6C4–5) background,

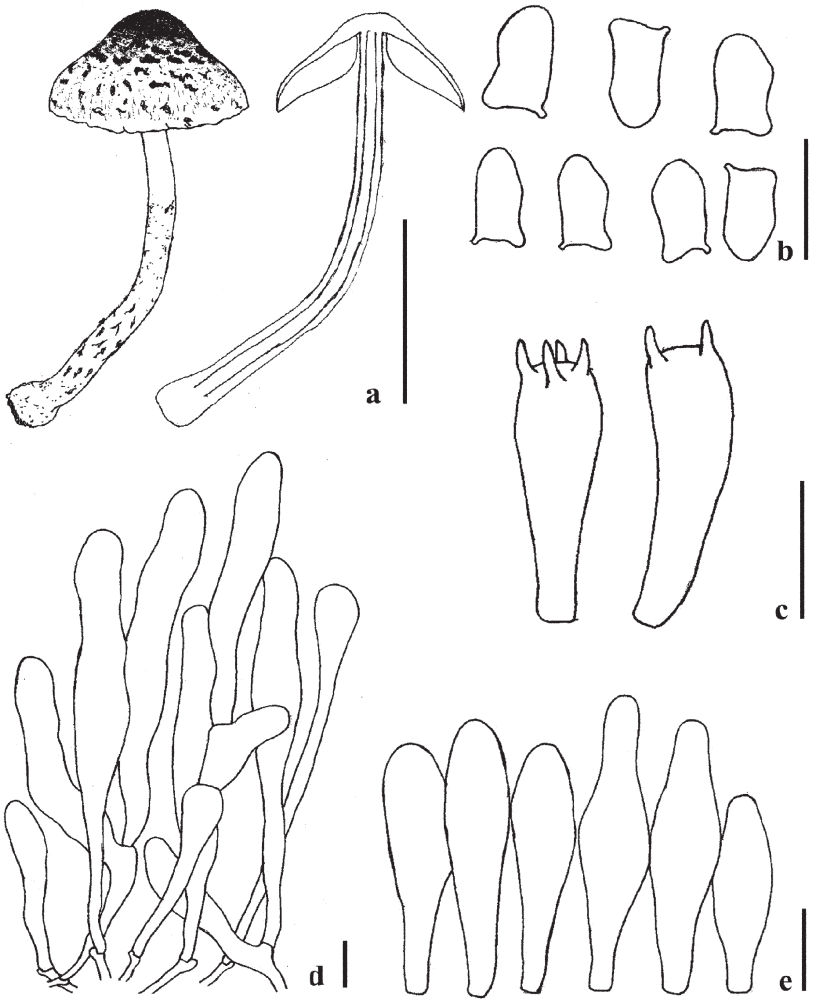

Figure 8. *Lepiota griseovirens* (MFLU100554).
a. basidiomata and a section; b. basidiospores; c. basidia; d. pileus covering; e. cheilocystidia.
Scale bars: a = 10 mm; b–e = 10 μm.

with white mycelium cords, hollow. Context in pileus white, 1.5–2 mm wide, in stipe concolorous with surface. Smell fruity. Taste unknown. Spore print white.

Basidiospores [50,2,1] in side view 6.2–7.0 × 3.5–4.2 μm, avl × avw = 6.7 × 3.8 μm, Q = 1.5–1.8, avQ = 1.7, oblong, with truncate base, with hilar

appendage, thick-walled, strongly dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl blue. Basidia 17–20 × 5.5–7 µm, clavate, 4-spored, often with 2 sterigmata. Lamella edge sterile. Cheilocystidia 22–30 × 6–8 µm, clavate, narrowly clavate, narrowly utriform. Pleurocystidia absent. Pileus covering a trichoderm made up of cylindrical to narrowly fusiform elements, without short clavate elements at base, 40–140 × 7.0–13 µm, thin-walled, with brown parietal pigment; basal hyphae cylindrical and hyaline, 7.5–12.5 µm wide. Stipe covering (squamules) a trichoderm as pileus covering. Clamp connections present in all tissues.

Habitat and distribution—growing in a small group with few basidiomata, terrestrial, and saprotrophic on ground of rain forest with dominant pine. This is the first record for Thailand. Also known from Europe (Vellinga 2001, Bon 1993).

Material examined: **THAILAND**, **Chiang Rai Prov.**, Mae Fa Luang Distr., Doi Tung National Park, 17.VII.2010, P. Sysouphanthong, MFLU100554.

Discussion—*Lepiota griseovirens* is rare in Thailand and was only found once, in Doi Tung National Park. The Thai collection is characterized by grayish brown to black pileus squamules that sometimes have a green to olive-brown hue. Its spores fall into the lower part of the range recorded for European collections (Vellinga 2001), but all other characters (including shape of the cheilocystidia) fit well with the European species concept.

Vellinga & Huijser (1993) discussed the naming of this species, which was then mainly known as *L. pseudofelina*. The two nrITS collections labeled as *L. pseudofelina* in Figure 2 previously were referred to two different names: *L. pseudofelina* and *L. griseovirens.*

Lepiota infelix E. Horak, Sydowia 33: 133. (1981). Fig. 9

Pileus 19–23 mm, when young convex or with low umbo, expanding to plano-concave with low umbo, with straight or slightly inflexed margin, when young dark brown (7F5–6), soon breaking open into squamules, crowded and dark brown (7F5–6) at centre and umbo, with fibrillose to fibrillose light brown to brown (6D7–8) squamules around centre toward margin, on white fibrillose background; margin split, fringed, exceeding lamellae when mature. Lamellae free, slightly crowded, ventricose, 3 mm wide, white, fragile, with white eroded edge. Stipe 20–25 × 1.2–1.5 mm, cylindrical, slightly wider at base; background white at apical zone, darker down towards base, light brown (6D7) at base, when mature turning grayish orange to brownish orange (6B4, 6C4–6), with brown (6E5–7) squamules from centre down towards base, hollow. Annulus as annular zone, with squamules. Context in pileus white to pale yellow (3A2), 1 mm wide; in stipe concolorous with surface. Smell mild. Taste unknown. Spore print white.

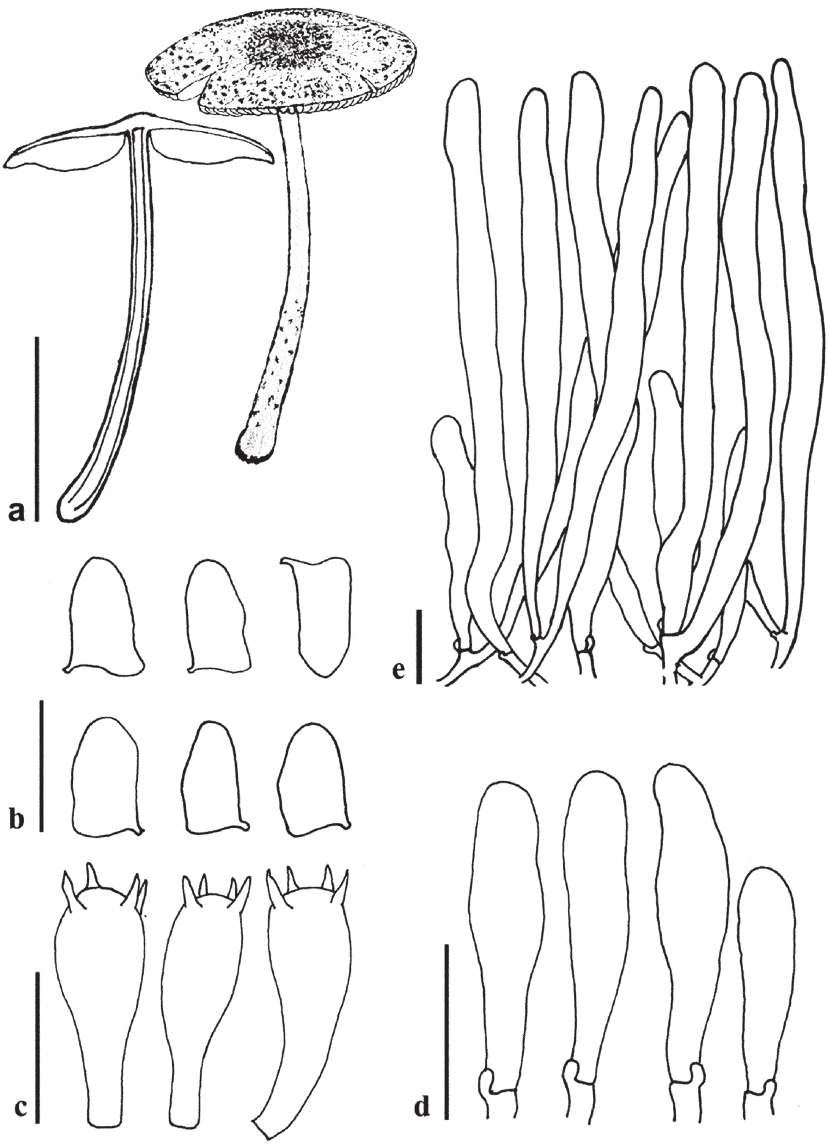

Figure 9. *Lepiota infelix* (MFLU090014).
a. basidioma; b. basidiospores; c. basidia; d. pileus covering; e. cheilocystidia.
Scale bars: a = 20 mm; b–e = 10 µm.

Basidiospores [25,2,1] 7.5–9.0 × 4.0–4.2 µm, avl × avw = 8.3 × 4.0 µm, Q = 1.7–2.2, avQ = 2.0, oblong to cylindrical, with rounded apex, with distinct spur at base, with or without lateral hilar appendage, in frontal view oblong, hyaline, slightly thick – walled, dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl blue. Basidia 15–18 × 6.0–8.0 µm, clavate, 4-spored. Lamella edge sterile. Cheilocystidia 16–25 × 5–7 µm, clavate to narrowly clavate, often utriform, colorless. Pleurocystidia absent. Pileus covering a trichoderm made up of cylindrical to narrowly clavate elements, 60–150 × 6–15 µm, slightly thick-walled, with pale brown parietal pigment, with under layer made up of hyaline to pale brown-walled, 3–6 µm wide, hyphae. Stipe covering a trichoderm, similar to pileus covering. Clamp connections present in all tissues.

Habitat and distribution—growing in a small group, saprotrophic and terrestrial on nutrient-rich soil, in deciduous rain forest with dominant *Lithocarpus* spp. In Thailand known from one locality. Found in Papua New Guinea (Horak 1981), and reported from India (Natarajan & Manjula 1983). This is a new record for Thailand.

Material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Taeng Distr., Pha Deng Village, 19°07′13.7″N, 98°43′52.9″E, 905 m alt., 11.VII.2007, P. Sysouphanthong, MFLU090014.

Discussion—*Lepiota infelix,* originally described from Papua New Guinea by Horak (1981), is characterized by reddish brown pileus and stipe squamules. The species resembles *L. ignipes* in pileus color, but the slender basidiospore shape in *L. infelix* separates the two taxa.

The also similar *L. alopochroa*, described from Sri Lanka and recorded from New Zealand (as *Lepiotula alopochroa*, Horak 1980), Papua New Guinea (Horak 1981), and now northern Thailand, differs in the color of the pileus squamules.

Lepiota papillata Sysouphanthong, K. D. Hyde, Chukeatirote & Vellinga, **sp. nov.**

Mycobank MB 519794 Fig. 10

Pileus 9–15 mm, conico-convexus dein campanulatus, umbonatus, vel papillatus, squamuloso-fibrillosus, brunneo-griseus vel olivaceo-brunneus. Lamellae liberae, albae dein pallide luteae. Stipes 25–30 × 1.5–2 mm, cylindricus vel subclavatus, squamuloso-fibrillosus. Basidiosporae 7.2–11.8 × 4.0–4.8 µm, calcaratae. Cheilocystidia 30–52 × 6–29 µm, cylindracea, clavata. Epicutis ex cellulis substrictis fusoideo-cylindraceis. Fibulae adsunt.

Holotypus: Thailand, Chiang Mai Prov., Mae Taeng Distr., Hot Spring National Park, 16°06′16.1″N, 99°43′07.9″E, 780–805 m alt., 9.VIII.2007, P. Sysouphanthong PNG041 (MFLU090041, **holotype**).

Etymology: '*papillata*' means with a papilla, referring to the shape of the pileus and of the pileus covering elements.

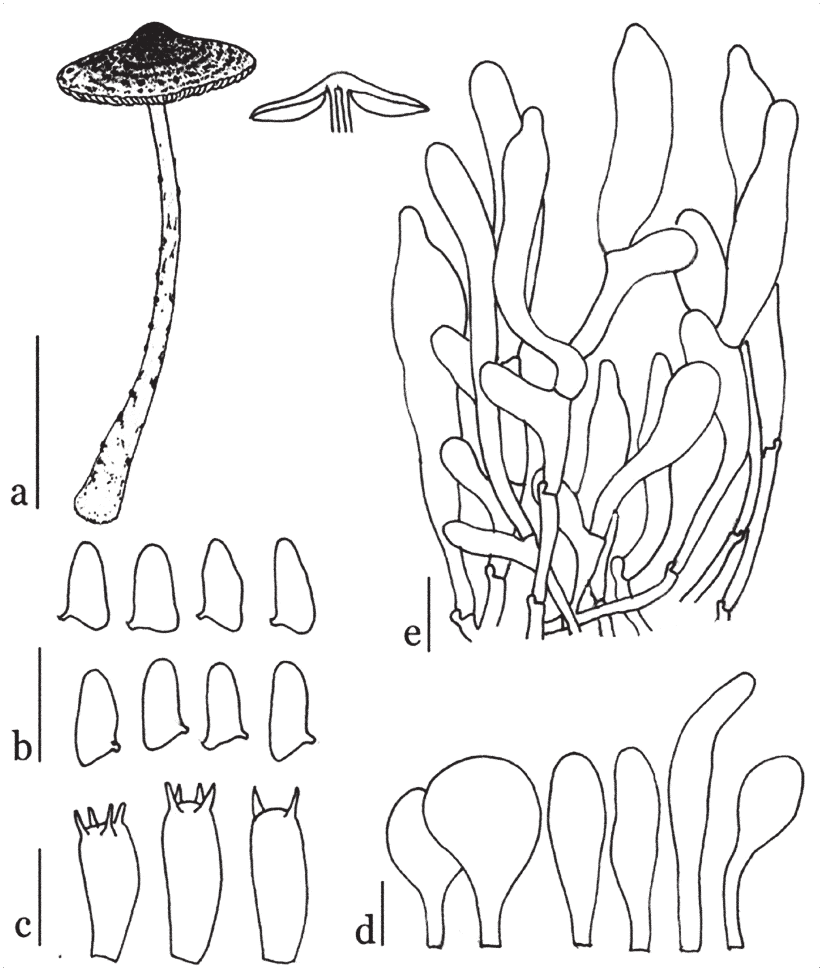

Figure 10. *Lepiota papillata* (MFLU090041).
a. basidioma; b. basidiospores; c. basidia; d. cheilocystidia; e. pileus covering.
Scale bars: a = 10 mm; b–e = 10 μm.

Pileus 9–15 mm, conical at first, expanding to campanulate, umbonate with umbo or high papilla, with inflexed margin, applanate to slightly plano-concave with uplifted margin; background brown (5F4), white to yellowish brown (5E5) on margin, covered with crowded brownish gray to olive brown (4F2–3) squamules at umbo, with brown (6E6) fibrillose squamules around umbo toward margin; margin split, slightly appendiculate, exceeding lamellae. Lamellae free, slightly crowded, ventricose,1.5–2 mm wide, when young white, yellowish

white to pale yellow (4A2–3) when mature, turning grayish orange (5B5) when dried, with serrate concolorous edge. Stipe 25–30 × 1.5–2 mm, cylindrical or slightly tapering upward, with orange-white to grayish red (5A2–7B4) background at apex, grayish orange to brownish orange (5B4–6C5) at center to base, turning brown (6D7) when bruised, covered with brownish gray to olive-brown (4F2–3) squamules from annular zone to base, with orange-white to brownish orange (5A2–6C5) fibrils between squamules; hollow. Annulus with annular zone, with squamules as stipe covering. Context in pileus white, less than 1 mm wide; in stipe grayish orange (5–6B6). Smell grass-like. Taste mild. Spore print white.

Basidiospores [50,2,1] 7.2–11.8 × 4.0–4.8 μm, avl × avw = 8.2 × 4.1 μm, Q = 1.8–2.5, avQ= 2.0, with straight or outgrown spur, cylindrical to oblong, with rounded or more acute apex, in frontal view oblong to cylindrical fusiform, with or without hilar appendage, hyaline, slightly thick-walled, not strongly dextrinoid in Melzer's reagent, congophilous, cyanophilous, not metachromatic in Cresyl blue. Basidia 12–20 × 5.5–7.5 μm, clavate, 4-spored, rarely 2–spored. Lamella edge sterile. Cheilocystidia 30–52 × 6–29 μm, variable in shape, clavate to narrowly clavate, slightly cylindrical, sometimes pyriform, spathulate, rarely narrowly clavate with long pedicel, hyaline, thin – walled. Pleurocystidia absent. Pileus covering a trichoderm made up of erect narrowly clavate elements 30–130 × 5.5–23 μm, with rounded apex, often with abrupt apical excrescence, pale brown-walled, with parietal and intracellular brown pigment, with cylindrical hyphae in under layer, thin-walled, 2.5–5.0 μm wide. Stipe covering in squamules a trichoderm similar to pileus covering. Clamp connections present in all tissues.

Habitat and distribution—growing in small group, saprotrophic and terrestrial, on humus-rich, nutrient-rich soil and dead leaves, found during rainy season in rain forest with dominant bamboo. Only known from one locality in northern Thailand.

Discussion—*Lepiota papillata* resembles *L. griseovirens* but differs especially in the pyriform, spathuliform to narrowly clavate shape of the cheilocystidia (which are narrowly utriform, obovoid, to nearly cylindrical cheilocystidia in *L. griseovirens;* Vellinga 2001) and in the abrupt apical excrescences often found on the pileus covering elements.

Lepiota grangei (Eyre) Kühner comes close in morphology but differs in the dark gray-green, grayish blue, green-brown, or blue-brown to brown pileus, the cylindrical to utriform cheilocystidia, and the intracellular pigment in the long pileus covering elements.

This species comes very close to *L. tomentella* J.E. Lange in pileus color and basidiospore size, but the latter has longer pileus covering elements that lack abrupt apical excrescences (Vellinga & Huijser 1993).

Lepiota pilodes Vellinga & Huijser differs from *L. papillata* by dull orange-brown to dark brown and ochraceous brown colors at centre of pileus, and longer pileus- and stipe-covering elements (60–280(–330) × (6.5–)8.0–21 µm; Vellinga & Huijser 1993, Vellinga 2001).

Lepiota poliochloodes Vellinga & Huijser, Persoonia 15: 229. 1993. Fig. 11

Misapplied names: *Lepiota griseovirens* sensu Bon (1993), Reid (1972); *Lepiota griseovirens* var. *griseovirens* sensu Bon (1981).

Pileus 12–25 mm, campanulate to umbonate, applanate to plano-concave with wide umbo, with straight margin, at centre with crowded squamules to small plush-like squamules or floccules, grayish brown, grayish green brown to dark brown (Mu. 2.5 Y 4–5/2, 6E3–6, 6F5–6), with squamules or fibrils around umbo toward margin and distant at marginal zone, on brownish orange, slightly orange or light brown fibrillose background (5C4, 6D4); margin peeling from background when mature, exceeding lamellae. Lamellae, L = around 40, l = 0–3, crowded to moderately crowded, just free, ventricose, 1.7–3 mm wide, white to yellowish white, distinctly pinkish cream (4A2, Mu. 10 YR 8/6), with eroded to floccose, distinctly cystidiose edge. Stipe 25–36 × 1–2.5 mm, cylindrical and slightly wider at middle, with white or yellowish white to orange-white or pale pink (4A2, 5A2) fibrillose background, with dark brown to dark gray-green (6F5–6) squamules from annular zone to base, with white to yellowish white (4A2) fibrils between squamules, hollow, with white rhizomorphs at base. Annulus an annular zone, with gray-green to dark brown squamules. Context in pileus white to pale cream, 1.5–2 mm wide, in stipe white, yellowish white (4A2) to pale orange. Smell mild. Taste unknown. Spore print white.

Basidiospores [70,3,3] 6.2–8.2 × 3.0–3.8 µm, avl × avw = 7.2 × 3.5 µm, Q = 1.6–2.4, Qav = 2.0, in side-view cylindrical or narrowly triangular with or without lateral spur, but spur not protruding abaxially, and with rather abrupt base, in frontal view cylindrical, with rounded apex or tapering toward apex, with 1 or 2 guttules, congophilous, dextrinoid, cyanophilous, not metachromatic in Cresyl Blue. Basidia 15–19 × 6 – 8 µm, 4-spored, rarely 2-spored, relatively short and plump. Lamella edge sterile. Cheilocystidia 18–40 × 3–9 µm, mostly cylindrical, to very narrowly clavate, some narrowly lageniform or slightly fusiform, strangulate, digitate. Pleurocystidia absent. Pileus and stipe covering a trichoderm or slightly irregular trichoderm made up of erect cylindrical, narrowly clavate to narrowly lageniform elements, (20–)30–130 × 6.5–15 µm, with pale brown walls, and with intracellular brown pigment, thin-walled, with under layer made up of cylindrical, hyaline, 2.5–9.0 µm wide hyphae. Clamp connections present in all tissues.

Habitat and distribution—growing solitary, saprotrophic and terrestrial in deciduous forest and bamboo forest. Reported from the Netherlands,

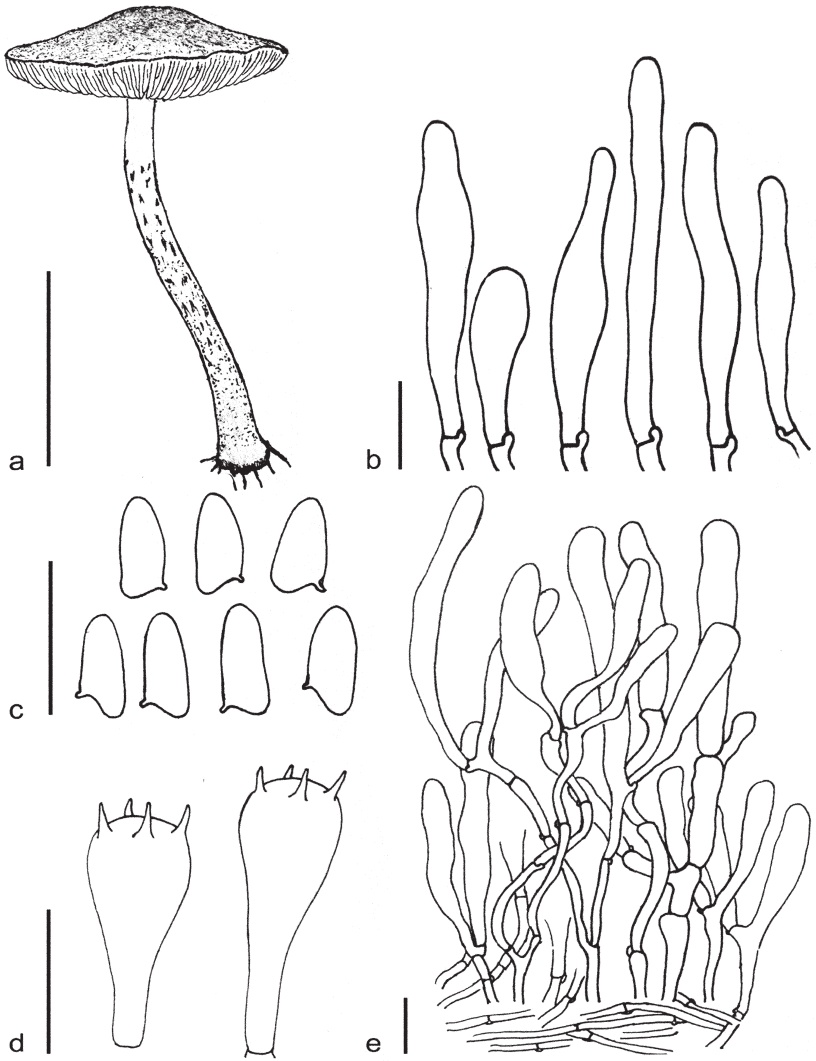

Figure 11. *Lepiota poliochloodes* (MFLU090182).
a. basidioma; b. cheilocystidia; c. basidiospores; d. basidia; e. pileus covering.
Scale bars: a = 20 mm; b–d = 10 μm; e = 20 μm.

Denmark, France, and Great Britain (Vellinga 2001); this is the first record for Thailand.

Material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Taeng Distr., Mae Sae village, 19°07′13.7″N, 98°43′52.9″E, 905 m alt., 8.VIII.2008, P. Sysouphanthong,

MFLU090182; Mok Fah Waterfall National Park, 20°02′43.1″N, 99°52′35.0″E, 596 m alt., 5.VII.2008, P. Sysouphanthong, MFLU090118; Mae Rim Distr., Mae Sa Valley, 12.VII.2008, J-K. Liu (collection ecv3877), MFLU081272.

Discussion—*Lepiota poliochloodes* is rare in Northern Thailand, where it is known from three localities. The macro- and micromorphology of the Thai material agree with the description of *L. poliochloodes* from Europe (Vellinga & Huijser 1993); unfortunately, there are no European nrITS sequence data available for comparison.

The relatively small spores and short pileus-covering elements combine with the pileus with grayish brown to green colors over a slightly orange background to characterize this species.

Lepiota griseovirens, which has similarly sized basidiospores and cheilocystidia differs from *L. poliochloodes* in the much darker basidiomata and the longer pileipellis elements.

***Lepiota* sp. 1** Fig. 12

Pileus 15 mm, plano-convex with umbo and slightly inflexed margin, at umbo not completely closed, with tufted scales; around umbo scales are more spreading out on yellowish background; scales small and reddish brown (Mu. 2.5 YR 3/4–6). Lamellae, L = around 35, l = 1–3, free, not very crowded, slightly ventricose, yellowish (Mu. 10 YR–2.5 Y 8/4) with lighter, slightly cystidiose edge. Stipe 24 × 2 mm, cylindrical, above annular zone innately lengthwise fibrillose, pale brown, below annular zone with small patches, sometimes spiny, of same material and color as on pileus, hollow, with white rhizomorphs. Smell a bit unpleasant, when old astringent.

Basidiospores [20,1,1] in side view 7.1–8.4 × 2.8–4.2 µm, avl × avw = 7.8 × 3.2 µm, Q = 1.9–2.8, avQ = 2.4, with distinct basal spur, in some spores spur also abaxially bulging, with round to slightly amygdaliform apex, in frontal view obovoid to subcylindrical, thick-walled, smooth, dextrinoid, and congophilous. Basidia 15–22 × 6.5–8.0 µm, 4-spored, some 2-spored, with basal clamp connection. Lamella edge sterile. Cheilocystidia 22–28 × 7.0–10.5 µm, utriform, fusi-utriform, and narrowly clavate, with basal clamp-connection. Pleurocystidia absent. Pileus covering trichodermal, made up of erect elements, 52–170 × 7.5–12.5 µm, cylindrical with rounded apex, almost always narrowed into pedicel, some very narrowly lageniform, with intracellular brown pigment. Stipe covering similar to pileus covering. Clamp connections present in all tissues.

Habitat and distribution—solitary, saprotrophic on humus rich soil in orchard with bamboo; only collected once close to Chiang Mai.

Material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Rim Distr., Mae Sa Valley, 12.VII.2008, leg. J-K. Liu (collection E.C. Vellinga 3881), MFLU08-1259.

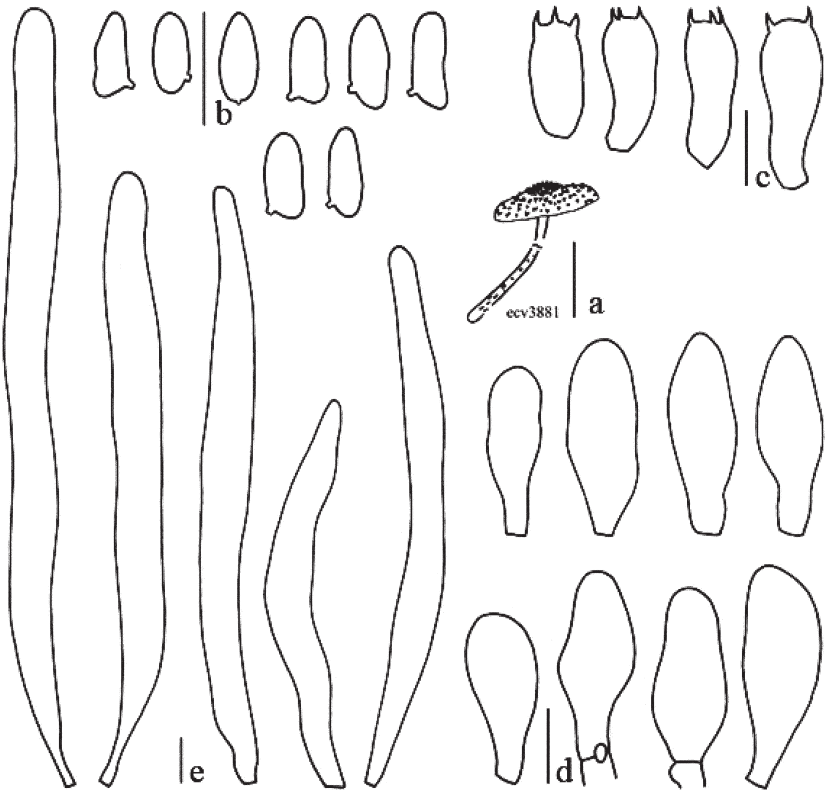

Figure 12. *Lepiota* sp. 1 (MFLU081259).
a. basidioma; b. cheilocystidia; c. basidiospores; d. basidia; e. pileus covering elements.
Scale bars: a = 1 cm; b–d = 10 µm.

Discussion—Macroscopically, this undescribed taxon resembles *L. echinella* Quél. & G.E. Bernard because of the tufted reddish brown pileus scales but differs in the spurred spores and shorter elements in the pileus covering.

We refrain from describing this taxon as a new species, as the sole collection contained only one specimen.

***Lepiota* sp. 2** Fig. 13

Pileus 30 mm, campanulate or umbonate with broad umbo, with straight margin, covered with crowded grayish brown to slightly reddish brown (8F6–8) squamules at center and around umbo toward margin and there more radially fibrillose, on grayish yellow (4B3), white to yellowish white (4A2), radially

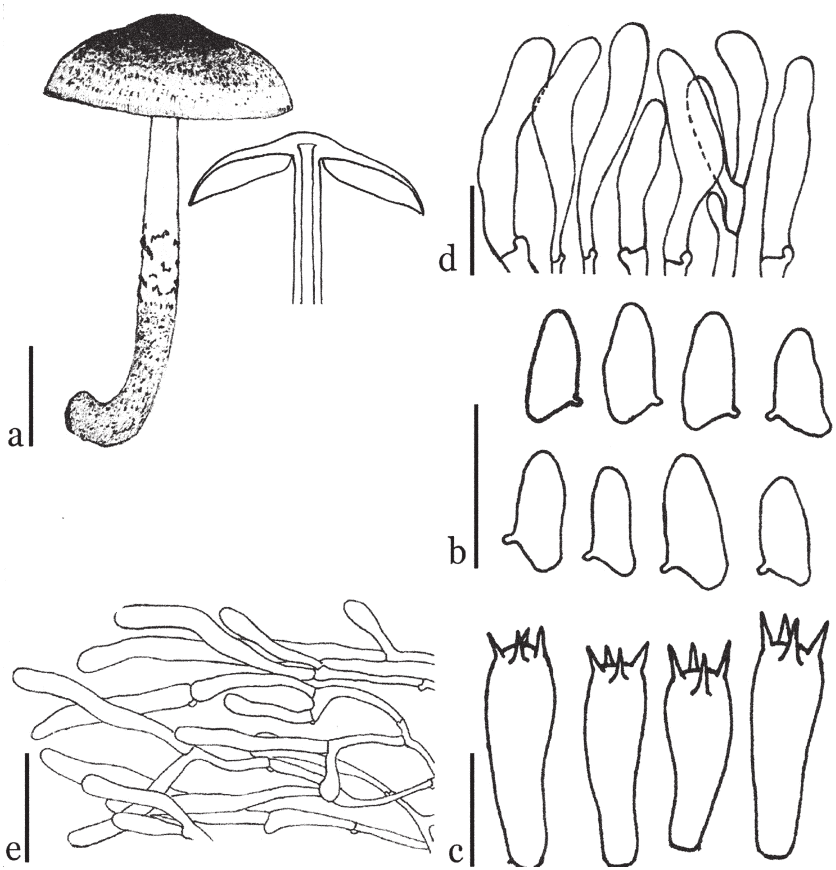

Figure 13. *Lepiota* sp. 2 (MFLU090006).
a. basidioma and context; b. cheilocystidia; c. basidiospores; d. basidia; e. pileus covering.
Scale bars: a = 10 mm; b–d = 10 µm; e = 20 µm.

fibrillose background; margin exceeding lamellae. Lamellae free, crowded, broadly ventricose, 2.5–3 mm wide, white to yellowish white (3A2), with slightly wavy edge. Stipe 40 × 3–4 mm, cylindrical, slightly wider at center and tapering to apex and curved at base; surface with white to pale orange (5A3) fibrils, with squamules from middle downwards, concolorous with squamules on pileus, with yellowish brown (5E5) fibrillose squamules at basal zone. Context in pileus thick at umbo, 4 mm wide, white to yellowish white (3A2); in stipe pale orange (6A3), hollow. Smell *Termitomyces*-like. Taste sweet. Spore print white.

Basidiospores [25,1,1] 6.2–8.0 × 3.2–4.0 µm, avl × avw = 7.3 × 3.7 µm, Q = 1.6–2.5, Qav = 1.9, in side-view with truncate to spurred base, oblong to cylindrical triangular or with curved abaxial side, sometimes with rounded or acute apex, in frontal view oval or cylindrical, strongly dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl blue. Basidia 16–21 × 7.0–8.0 µm, narrowly clavate, 4–spored, hyaline, thin-walled. Lamella edge sterile, with crowded cheilocystidia. Cheilocystidia 12–45 × 5.2–10 µm, cylindrical, sometimes narrowly lageniform, narrowly clavate, with rounded apex, subcapitate, sometimes slightly swollen at center, utriform, colorless, thin-walled. Pleurocystidia absent. Pileus covering a cutis made up of irregular narrowly clavate hyphae, 25–128 × 10–18 µm, usually narrowed into pedicel, with rounded or subcapitate apex, slightly thick-walled, with or without septum, with basal clamp connections, with yellowish brown parietal pigment; under layer made up of cylindrical 3.0–7.0 µm wide hyphae, thin-walled, with yellowish brown walls in upper part, with hyaline walls in lower part. Stipe covering a cutis similar to pileus covering. Clamp connections present in all tissues.

Habitat and distribution—growing solitary, saprotrophic and terrestrial on humus-rich soil with dead leaves and wood, in deciduous forest with *Lithocarpus* spp. Only found in one locality in northern Thailand.

Material examined: **THAILAND**, **Chiang Mai Prov.**, Mae Taeng Distr., Pha Deng Village, 19°07′13.7″N, 98°43′52.9″E, 905 m alt., 19.VII.2007, P. Sysouphanthong, MFLU090006.

Discussion—This undescribed taxon is characterized by grayish brown to reddish brown squamules on pileus and stipe, truncate to spurred basidiospores, cylindrical to narrowly clavate cheilocystidia, and a cutis-like pileus covering.

Lepiota griseovirens, which can be confused with this species in the field because of the color of the pileus squamules, differs in the trichodermal pileus covering.

Here also the single collection comprised only one basidioma, and we were unable to obtain nrITS sequence data. We await further collections before proposing a name.

Acknowledgements

We wish to acknowledge the Mushroom Research Centre in Mae Taeng District, Chiang Mai Province, Thailand for providing funding, and facilities for collecting and study. The International Fungal Research and Development Centre, The Research Institute of Insect Resources (RIRI) is thanked for providing materials and laboratory facility for the molecular work. Funding of ECV and PS in 2007–2009 by NSF grant DEB 0618293 is gratefully acknowledged. This study was also partially supported by the project "Value added products from Basidiomycetes: Putting Thailand's biodiversity to use" (BRN049/2553). The comments by the two reviewers, Dr R.-L. Zhao and Dr Zai-Wei Ge, are gratefully acknowledged.

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